PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 33072/101111	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US03/36836	International filing date *(day/month/year)* 17 November 2003 (17.11.2003)	Priority date *(day/month/year)* 15 November 2002 (15.11.2002)
International Patent Classification (IPC) or national classification and IPC IPC(7): G06T 15/00 and US Cl.: 345/419, 421, 422, 423, 424, 426, 427, 428, 441, 552, 581		
Applicant SUNFISH STUDIO, INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 13 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☒ Priority
   - III ☒ Non-establishment of report with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☒ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
28 July 2004 (28.07.2004)	18 January 2005
Name and mailing address of the IPEA/US Mail Stop PCT, Attn: IPEA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer Kimbinh Nguyen Telephone No. (703) 305-9683

Form PCT/IPEA/409 (cover sheet)(July 1998)

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I. Basis of the report

1. With regard to the elements of the international application:*

☒ the international application as originally filed.

☒ the description:
pages 1-34 as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

☒ the claims:
pages NONE, as originally filed
pages NONE, as amended (together with any statement) under Article 19
pages NONE, filed with the demand
pages 35-47, filed with the letter of 27 September 2004 (27.09.2004)

☒ the drawings:
pages 1-20, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

☐ the sequence listing part of the description:
pages NONE, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of _____.

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination(under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages NONE

☒ the claims, Nos. 18,29

☐ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*
*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

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II. Priority

1. ☒ This report has been established as if no priority has been claimed due to the failure to furnish within the prescribed time limit the requested:

   ☒ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).

   ☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).

2. ☐ This report has been established as if no priority has been claimed due to the fact that the priority claim has been found invalid (Rule 64.1).

Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.

3. Additional observations, if necessary:

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III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The question whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been and will not be examined in respect of:

☐ the entire international application,

☐ claims Nos. _____

because:

☐ the said international application, or the said claim Nos. _____ relate to the following subject matter which does not require international preliminary examination *(specify)*:

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. _____ are so unclear that no meaningful opinion could be formed *(specify)*:

☐ the claims, or said claims Nos. _____ are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for said claims Nos. _____

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

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V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. STATEMENT

Novelty (N)	Claims	NONE	YES
	Claims	1-17,19-28,30-50	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-17,19-28 and 30-50	NO
Industrial Applicability (IA)	Claims	1-17,19-28 and 30-50	YES
	Claims	NONE	NO

2. CITATIONS AND EXPLANATIONS

Claims 1-17, 19-28 and 30-50 lack an inventive step under PCT Article 33(3) as being obvious over Kant et al. (6,772,136) in view of Snyder "Interval Analysis For Computer Graphics", ACM, published July 1992, pages 121-130.

Kant et al.teaches image synthesis method (synthesis process; col. 16, lines 61-67), comprising: executing an interval branch and bound method (col. 18, line 20 through col. 22, line 23) to compute shading values for pixels; splitting (col. 27, lines 52-53); non-linear equation (col. 33, lines 17-63). Kant et al. does not teach implicit function; however, Snyder teaches interval analysis for computer graphics including ray tracing of implicit surfaces (approximating implicit curves (see pages 121-128). It would have been obvious to one of ordinary skill in the art at the time the invention was made to incorporate the implicit functions taught by Snyder into the synthesis system using interval analysis of Kant for approximating parametric surface using interval arithmetic (nonlinear equation system), because implicit curve is the solution to a constraint system and are extremely useful in geometric modeling, especially for CSG and trimming operations on parametrically described shapes and variety important problems in computer graphics can be solved either directly, or when used in a higher level algorithm such as the implicit curve approximation algorithm (see conclusion, page 128).

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VI. Certain documents cited

1. Certain published documents (Rule 70.10)

Application No Patent No.	Publication Date *(day/month/year)*	Filing Date *(day/month/year)*	Priority date (valid claim) *(day/month/year)*
6,772,136	3/8/2004	3/1/2001	21/8/1997

2. Non-written disclosures (Rule 70.9)

Kind of non-written disclosure	Date of non-written disclosure *(day/month/year)*	Date of written disclosure referring to non-written disclosure *(day/month/year)*

What is claimed is:

1. In a photorealistic image synthesis method wherein stored digital representations of physical three dimension object scenes are selectively input, and one or more user-defined shading routines are selectively called upon in the course of assessment of the stored digital representations of physical three dimension scenes in furtherance of the production of a rectangular output array of pixels representing the visible set of surfaces of each of the stored digital representations of physical three dimension scenes, the step comprising:

a. executing an interval branch-and-bound method to compute shading values for pixels, to a user specified certainty, of the rectangular output array of pixels representing the visible set of surfaces of each of the stored digital representations of physical three dimension scenes by successively splitting each object of the objects of the physical three dimensional object scenes, said each object having a surface delimited by a geometric primitive.

2. The photorealistic image synthesis method of claim 1 wherein said geometric primitive is a parametric function.

3. The photorealistic image synthesis method of claim 2 wherein an interval analysis is performed over a parametric domain of said each object of the objects of the physical

three dimensional object scenes.

4. The photorealistic image synthesis method of claim 3 wherein consistency is evaluated against a domain of a screen coordinate system.

5. The photorealistic image synthesis method of claim 2 wherein unknown parametric variables in a system of nonlinear equations describing each object of the objects of the physical three dimensional object scenes are ascertained using interval analysis.

6. The photorealistic image synthesis method of claim 5 wherein consistency is evaluated against a domain of a screen coordinate system.

7. The photorealistic image synthesis method of claim 6 wherein a solution set of parametric variables is input to the one or more user-defined shading routines.

8. The photorealistic image synthesis method of claim 7 wherein an assessment of consistency against said screen coordinate system includes transformation of boxes representing select areas within said local coordinate system into said coordinate system of said screen.

9. The photorealistic image synthesis method of claim 8 wherein splitting of said successive splitting each object of the objects of the physical three dimensional object scenes is first performed in x and y dimensions.

10. The photorealistic image synthesis method of claim 9 wherein said splitting is terminated upon satisfying a user-specified dimension criteria for either said x or said y dimension.

11. The photorealistic image synthesis method of claim 10 wherein said user-specified dimension criteria for either said x or said y dimension is a pixel subunit.

12. The photorealistic image synthesis method of claim 10 wherein subsequent to termination of said splitting in said x and y dimensions, further splitting is performed in a z dimension.

13. The photorealistic image synthesis method of claim 12 wherein, for opaque objects, said z dimension is successively split in a direction extending outwardly from a view point so as to find a first root.

14. The photorealistic image synthesis method of claim 13 wherein, for transparent objects, said z dimension is further

successively split in a direction extending from a user selected distal extremity in said z dimension inwardly toward a view point so as to find all roots.

15. The photorealistic image synthesis method of claim 14 wherein a set inversion is performed to sharpen unknown parametric variables.

16. The photorealistic image synthesis method of claim 15 wherein, subsequent to said sharpening of unknown parametric variables, such box is shaded and sent to said output array of pixels.

17. The photorealistic image synthesis method of claim 16 wherein all boxes contributing to an area of a pixel are integrated to generate a single output result for said pixel.

18. The photorealistic image synthesis method of claim 17 wherein integration of said all boxes contributing to an area of a pixel are importance filtered.

19. The photorealistic image synthesis method of claim 1 wherein said geometric primitive is an implicit function.

20. The photorealistic image synthesis method of claim 19 wherein an interval set inversion is performed over a domain

of a screen coordinate system.

21. The photorealistic image synthesis method of claim 20 wherein, in furtherance of assessment of consistency against said screen coordinate system, boxes representing areas in a local coordinate system are transformed into said coordinate system of the screen.

22. The photorealistic image synthesis method of claim 21 wherein splitting of said successive splitting each object of the objects of the physical three dimensional object scenes is first performed in x and y dimensions.

23. The photorealistic image synthesis method of claim 22 wherein said splitting is terminated upon satisfying a user-specified dimension criteria for either said x or said y dimension.

24. The photorealistic image synthesis method of claim 23 wherein said user-specified dimension criteria for either said x or said y dimension is a pixel subunit.

25. The photorealistic image synthesis method of claim 22 wherein subsequent to termination of said splitting in said x and y dimension, further splitting is performed in a z dimension.

26. The photorealistic image synthesis method of claim 25 wherein, for opaque objects, said z dimension is successively split in a direction extending outwardly from a view point so as to find a first root.

27. The photorealistic image synthesis method of claim 26 wherein, for transparent objects, said z dimension is further successively split in a direction extending from a user selected distal extremity in said z dimension inwardly toward a view point so as to find all roots.

28. The photorealistic image synthesis method of claim 27 wherein all boxes contributing to an area of a pixel are integrated to generate a single output result for said pixel.

29. The photorealistic image synthesis method of claim 28 wherein integration of said all boxes contributing to an area of a pixel are importance filtered.

30. A system for visible surface determination in furtherance of photorealistic rendering in a computer graphics environment, said system comprising:

a. a scene database wherein visual characteristics of objects of an image frame of a scene of said scene database are delimited as geometric primitives; and,

b. a processor for executing an interval analysis, to a

user degree of certainty, for accurately and deterministically ascertaining a visible solution set of an area not exceeding a pixel dimension for a pixel of an array of pixels that form said image frame.